Center Innovation Fund: MSFC CIF

Production and Hot Hydrogen Testing of Molybdenum Matrix Cermet Fuels for NTP

Completed Technology Project (2017 - 2018)

Project Introduction

Through this CIF project, molybdenum (Mo) matrix cermets will be produced via an innovative direct current consolidation technique and hot hydrogen tested using surrogate materials in place of the uranium dioxide (UO2) particles. The objective of this CIF is to identify the maximum use temperature and characterize fuel system behavior under steady state and thermal cycling conditions for low absorbing Mo matrix fuels as an alternative to tungsten (W).

Anticipated Benefits

Through the use of a hydrogen (H2) propellant, nuclear thermal propulsion (NTP) is a non-chemical propulsion technology capable of high specific impulse (850 - 900 s) and thrust (100 - 1,100 kN) allowing for reduced trip times for crewed missions to beyond LEO. Neutronic analyses, undertaken by NASA partners, have predicted that low enriched uranium (LEU) fueled nuclear thermal rockets (NTRs) with <20% 235U enrichment can be designed to allow for comparable performance to high enriched uranium (HEU) alternatives. LEU engine designs are anticipated to significantly reduce the perceived high maintenance costs and political hurdles traditionally associated with developing HEU NTP systems. The successful development of a LEU engine requires the affordable production and qualification of a fuel form which allows for operation in excess of 2500 K, resists interaction with the H2 propellant, and exhibits the nuclear properties to enable engine criticality with reduced uranium enrichment. Through this Center Innovation Fund (CIF) project, molybdenum (Mo) matrix cermets were produced via an innovative direct current consolidation technique and hot H2 tested using surrogate materials in place of the uranium dioxide (UO2) particles.

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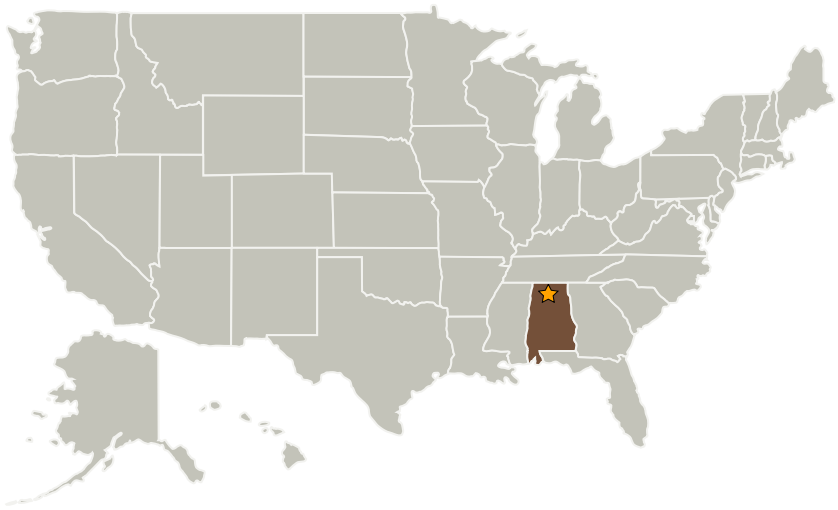
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Marshall Space Flight Center(MSFC)	Lead Organization	NASA Center	Huntsville, Alabama
Oak Ridge National Laboratory(ORNL)	Supporting Organization	R&D Center	Oak Ridge, Tennessee
The University of Tennessee-Knoxville(UT-K)	Supporting Organization	Academia	Knoxville, Tennessee

Primary U.S. Work Locations
Alabama

Project Transitions

October 2017: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Marshall Space Flight Center (MSFC)

Responsible Program:

Center Innovation Fund: MSFC CIF

Project Management

Program Director:

Michael R Lapointe

Program Manager:

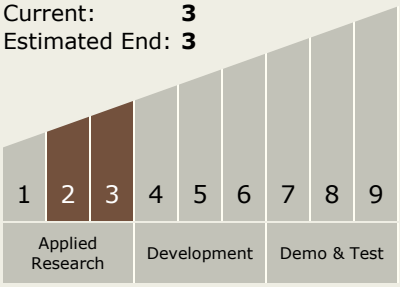
John W Dankanich

Principal Investigator:

Marvin W Barnes

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



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September 2018: Closed out

Closeout Summary: Molybdenum cermets for nuclear thermal propulsion applications have been produced via a two-step powder blending, spark plasma sintering process. Produced subscale samples coupons with cermet microstructures containing volume loadings of 40 - 70% ceramic particles have been demonstrated. Production parameter optimization has been performed and as-produced sample microstructures characterized to enable identification of production parameters which allow for the most desirable sample microstructures. As produced samples have been tested under steady state and thermal cycling conditions in hot flowing H2 at relevant timescales (up to 80 minutes) and temperatures (up to 2250 K) for NTP relevant conditions. Samples retained structural integrity throughout testing with minimal mass loss. Upcoming testing is planned to test cermet fuels under extreme temperatures (2500, 2750 K) in NTP relevant environments. Forward work aims to work to transition production processes from the lab scale to the production scale include assessing geometry, scalability effects and integration of relevant cladding techniques in order to demonstrate full length fuel elements. Future verification testing should aim to test Mo cermets to failure, in order to characterize total temperature dependent lifetime capability, as well as probe the effect of H2 pressure and flow rate on cermet fuel failure mechanisms.

Project Website:

https://www.nasa.gov/directorates/spacetech/innovation_fund/index.html#.VC

Technology Areas

Primary:

- TX01 Propulsion Systems
  - TX01.4 Advanced Propulsion
    - TX01.4.3 Nuclear Thermal Propulsion

Target Destinations

Mars, Others Inside the Solar System, Outside the Solar System